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IGY BULLETIN

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Use of a Temperature Telemetering System in Incubating Eggs of Antarctic Birds

This report is based on material supplied by Carl R. Eklund, Scientific Leader at US-IGY Wilkes Station during 1957–58, and Frederick E. Charlton, Electronics Technician Chief, USN. Part of the data is being used by Eklund in a doctorate thesis at the University of Maryland.

Ever since the Emperor Penguin (*Aptenodytes forsteri*) was first found incubating its eggs in the Antartic in temperatures as low as 77° below zero Fahrenheit, students of animal physiology have wondered how the embryos could develop in such cold. Establishment of stations in Antarctica by the United States during the IGY provided a rare opportunity to carry out studies of this question.

Because the Emperor has no fixed nest and may move many times while incubating an egg, a temperature instrument that could be contained within the egg was needed. Fortunately, the Office of Naval Research was contracting at this time for a miniature telemetering instrument to be used in human physiology studies. It would be ideal for the proposed work on polar animals.

The instruments were delivered in time for use during 1957 at the US-IGY Wilkes Station, located among the Windmill Islands of Vincennes Bay, on the Budd Coast of Wilkes Land, at 66°15′S, 110°31′E.

The area turned out to be very rich zoologically, but unfortunately no Emperor Penguins were nesting in the region. It was decided, therefore, to carry out the temperature studies on summer-nesting species such as the Adelie Penguin (*Pygoscelis adeliae*) and the South Polar Skua (*Catharacta maccormicki*). The studies were conducted over a 9-day period, December 11–19, 1957, at Adelie Penguin Rookery "A," on Clark Peninsula one-quarter mile from Wilkes Station.

An Adelie Penguin egg and a skua egg were emptied by cutting them in half lengthwise with an electric saw of the type used in handicraft work.

A tiny, elliptical moisture-proof transmitter was placed between the two halves of each eggshell and the edges cemented together. After the cemented eggs had dried, 30 cc of albumen were injected by syringe through 1/16-inch holes at the tops of the eggs, and the holes sealed with cement.

A transmitting egg, carefully calibrated against a standard thermometer, was substituted for one of the normal clutch of two in each nest. The second or normal egg acted as a control, and since it eventually hatched in each instance, this was taken as

indicative that the experimental egg had received a normal temperature. (Each transmitting egg was recalibrated on completion of the study.)

Each transmitter radiated a modulated electromagnetic signal, the number of pulses per second being proportional to the temperature inside the egg. This signal was intercepted by a loop antenna placed over the nest and relayed by transmission line to a low-frequency radio receiver in a nearby observers' shelter. There it was demodulated and sent to a pulse counter.

This unit, read at 15-min intervals, reflected temperature changes in the incubating egg within limits of 41° to 104°F. The study showed the average temperature of the incubating skua egg to be 96.6°F, with a maximum of 103.5°F and a minimum of 87°F. The average body temperature of this species is 106.1°F, ranging from a minimum of 103.4°F to a maximum of 108.4°F. The average temperature of the incubating egg was thus 9.5°F less than the average skua body temperature.

The average temperature of the incubating Adelie Penguin egg was 92.7°F, with a maximum of 98.2°F and a minimum of 84.5°F. The average body temperature of the Adelie is 103.8°F, ranging from a minimum of 100.3°F to a maximum of 106.4°F. Thus the average temperature of the incubating egg of the Adelie was 11.1°F less than its average body temperature, and 3.9°F less than the average temperature of the incubating skua egg.

The greater range in the incubating temperatures of the skua egg reflects the number of times the parent bird changed incubation duties with its mate. One of the pair of skuas under study was sprayed with green paint to provide easy differentiation of both birds on the nest. A continuous 132-hr record was kept; during this period the pair relieved each other in the nest 13 times, or an average of 2.36 times every 24 hrs. The Adelie Penguin, on the other hand, may not be relieved by its mate for as long as two weeks.

On the basis of temperature studies conducted on chicken embryos by C. Romijn and W. Lokhorst, it was found that a rise in body temperature of the embryo may be expected after the tenth day of incubation (about the first half of the total time required), when the heat production of the chick embryo increases rapidly. If similar action took place in the egg of the skua and the penguin, the temperatures obtained in this study would be valid only up to about the first 10 to 15 days, after which they would be affected by the embryo.

The theory of application and the basic design of the temperature telemeter were excellent for the work carried out, and it is believed that the instrument has possibilities for remote temperature studies in the field of physiology generally.

Reports on IGY Solar Eclipse Expedition

This report is based on material supplied by Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division, Naval Research Laboratory; Robert J. Low, Executive Officer, High Altitude Observatory; and Garth Stonehocker, Central Radio Propagation Laboratory, National Bureau of Standards.

The US-IGY expedition to the Danger Islands in the South Seas to observe the solar eclipse of October 12 was the most elaborate such expedition ever mounted (see *Bulletin No. 12*).

In addition to a scientific team aboard the USS *Point Defiance*, to handle the rocket experiment, there were five groups

of experimenters based on the islands. Herbert Friedman led the shipboard group of ten scientists and engineers from the Naval Research Laboratory. These included Talbot A. Chubb, John C. Lindsay, and Robert W. Kreplin, who were responsible for various phases of the rocket astronomy program. In the mounting and arming of the rockets, this group was assisted by Robert E. Cox and two engineers of the Cooper Development Corp. of Monrovia, California.

On the shore, John W. Evans of Sacramento Peak Observatory, Sunspot, New Mexico, led a group of 16 scientists from the High Altitude Observatory, the Central Radio Propagation Laboratory of the National Bureau of Standards, the University of Wisconsin, the California Academy of Sciences, and the Naval Radiological Defense Laboratory. Assisting the scientists were teams of Navy and Marine Corps specialists, including an underwater demolition team of seven frogmen, nine marines to pilot amphibious craft, and three helicopter pilots with a ten-man supporting group.

In addition to the American effort, a British and New Zealand expedition established a base on Atofu, a Japanese expedition took station on Suwarrow Island, and a Swiss party made observations on the coast of Chile.

Eight US observation and test projects were planned. Of these, four required clear skies and another required at least partly clear weather. Clouds obscured the sun just long enough to destroy these four experiments and seriously limit the validity of the measurements obtained by the fifth.

Three experiments could be carried out regardless of cloud cover; these were all successful. The NRL rocket flights, in particular, were an outstanding success. The Sacramento Peak—High Altitude Observatory group recorded changes in cosmic noise absorption at 18.5 mc/s, supplemented by observations of atmospherics received at 27 kc/s. (Atmospherics are radio signals originating in naturally-occurring electrical discharges in the earth's atmosphere, such as lightning flashes.) In addition, a very good set of ionospheric soundings with a C-2 vertical-incidence sounder was made by personnel of the NBS Boulder Laboratories (see Fig. 1).

Optical Experiments

The optical experiments that stood idle under the cloud-filled sky were intended to make line-profile measurements of the green and yellow emission lines of the sun's corona, to detect the polarization of the white light corona, to observe quantita-

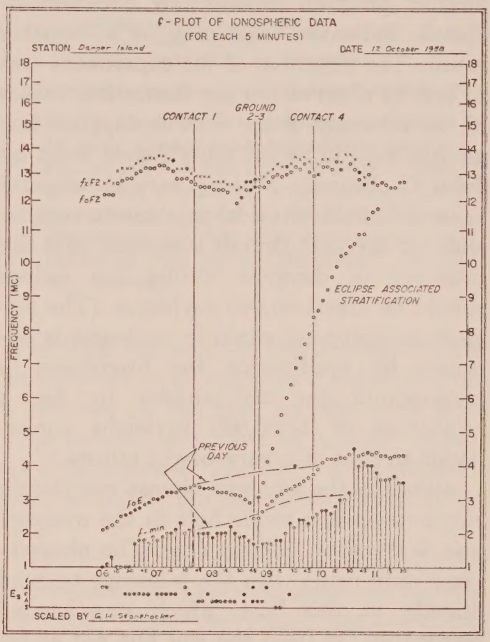

Fig. 1. *Graph of Frequency Against Time (f-plot) for the Eclipse Period, 0600–1130 Local Time, at 165°W. Sampling interval is five min. Both the critical frequency of the E-layer (f_0E) and the f-minimum started decreasing after first contact, dipped sharply near totality, then recovered to their normal values for that time of day. A stratification developed just above the E-layer and increased in both critical frequency and virtual height until it combined with the F2-layer critical frequency (f_0F2), about 1100; this phenomenon is usual during eclipses.*

tively, for the first time, "shadow bands" thought to be produced by variations in the earth's atmosphere, and, finally, to photograph rapid-sequence, medium-dispersion spectra of the chromosphere, the lowest layer of the sun's atmosphere.

A fifth experiment, an attempt by the National Bureau of Standards' Boulder Laboratories to observe the 6300 A neutral oxygen emission line of the daytime airglow, was partially successful in spite of the clouds.

Airglow studies: The airglow observations, carried out by Lawrence R. Megill and Edward Marovich of NBS, who have been working for some time in the NBS airglow program directed by Franklin E. Roach, indicated what may be a negative result. The objective of the experiment was to test by observation the theoretical values of the intensity of the 6300 A dayglow line as predicted in recent unpublished work by John C. Brandt. Making certain assumptions about the physical mechanism responsible for the line, Brandt suggested that the intensity of dayglow during the eclipse should be about 50,000 rayleighs. (The airglow intensity measured in rayleighs is obtained by multiplying the brightness in megaquanta per cm^2/sec/ster by 4π; a brightness of 1,000,000 rayleighs corresponds to that of a very bright aurora.)

Although the sky was almost completely cloud-covered, a single hole in the overcast was detected at eclipse time. The observations were made with the telescope pointed directly at this hole, which was located reasonably far from the sun but not as far as would have been desirable for the optimum detection of a terrestrial atmospheric-emission phenomenon.

The intensity of the radiation received was below the threshold of the instrument. This suggests that an upper limit may be established for the intensity of the line at a value substantially less than the predicted value, but the observational result is not easy to interpret because of the difficulty of determining quantitatively the effect of the clouds. This effect will strongly influence the calibration of the instrument; thus, at the present time the implications of the observation are uncertain. An effort is being made to untangle the conflicting factors.

Rocket Experiments

The rocket experiments were designed to measure X-ray and ultraviolet emissions from those portions of the sun which were uncovered during various stages of the eclipse. As an eclipse progresses, it is possible to measure the contributions of sunspot regions as they are covered or uncovered. During totality, the photosphere is completely covered and any residual radiation must come from the outermost layers of the chromosphere and from the corona. If a rocket is in the air for a few minutes leading up to second contact (when the moon covers the sun and the corona becomes visible) and for a corresponding interval just after third contact (when the sun begins to reappear), its detectors should see the variation of emission with altitude above the sun's limb, or edge, up to the top of the chromosphere and perhaps into the inner corona.

Rocketry: The Nike-Asp rocket combination selected for the experiment underwent a series of five test launchings from San Nicolas Island, California, during July and appeared to be well suited for the eclipse experiment. The Nike booster burns for about 3 sec, to a height of about 1 mi, where differential air drag separates the Asp from the booster. The Asp coasts to a height of 40,000 ft before it ignites. After burning for six seconds, the Asp reaches an altitude of 800,000 ft with its 75-lb payload and falls back to earth after a total flight time of 8 min.

A rocket operation aboard ship introduces certain difficulties. To avoid azimuth deviations in launching direction, it was necessary to fire when the ship was horizontal. This

was accomplished by the use of a gyrostabilizer which delayed the firing signal until the ship was horizontal within ± ¼°. Since the rockets could not have been safely handled in a rough sea, all mounting work was accomplished while the ship was docked in Samoa. Instrumentation sections were installed the day before the eclipse. Finally, expert navigation was required to locate the ship at the planned launching position, 40 mi from Pukapuka, at exactly the proper time.

Instrumentation: The instrumentation units for the rockets were equipped with detectors to measure X-rays in two wavelength bands, 8–18 A and 44–60 A, and Lyman-alpha emission of hydrogen in the ultraviolet at 1216 A. Photocell units were included to permit determination of rocket aspect throughout flight. Bendix FM-FM telemetering was employed, using frequencies of 228.5 and 219.5 mc/sec at 2 watts power output with four sub-carrier channels. Telemetered signals were received by means of antennas mounted in the muzzles of pairs of 3-in guns which could be trained to follow the flights of the rockets. Tape and oscillograph recordings were made in a trailer in the ship's well deck.

Shipboard Experiment: It was originally planned to launch two rockets for test purposes and background data on September 28 and October 1 and to launch six rockets on October 12 during the progress of the eclipse. Two of the six eclipse rockets were to be in the air during totality and the remaining four were to be distributed so as to observe portions of the disk exposed before second contact and after third contact.

On the day of the eclipse, the distribution of visible activity on the disk of the sun was as illustrated in Figure 2. It was then decided to launch the first rocket about 10 min before second contact to expose a crescent on the east limb containing a number of sunspots. The second and third rockets were to be fired during totality. Shortly

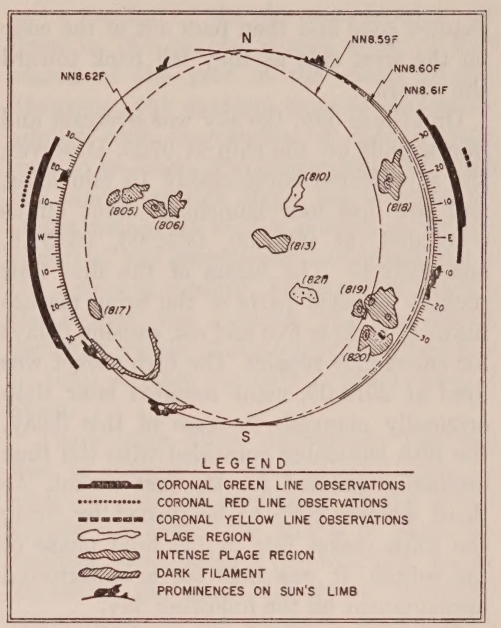

Fig. 2. *Appearance of Solar Disc on October 12, 1958. Dashed lines show edges of moon's disc projected on sun's disc at times of first four rocket launchings. Plage numbers (in parentheses) assigned by McMath-Hulbert Observatory. All data other than sunspot locations by High Altitude Observatory, Boulder, Colorado.*

after third contact, the fourth rocket was to be launched so as to measure radiation from a crescent of the disk on the west limb. This portion was clear of activity except for a prominence. The fifth and sixth shots were to follow the fourth at 10-min intervals.

The rockets were mounted on fixed launchers spaced in a pattern about the helicopter deck. Since the rocket measurements were to be made at ionospheric altitudes, it was necessary to shoot from outside the ground level shadow. At eclipse time the ship was headed on a course of 115°40′ northeast of Pukapuka at approximately 10°21′S, 165°28.8′W. The totality rockets were launched at an azimuthal angle of 295° in order to enter the eclipse shadow cone from the east at an altitude of about 120 mi. Assuming ideal performance, the rockets would reach a 150-mi altitude inside the

shadow cone and then pass out of the cone on the west side as they fell back toward the ocean.

On eclipse day, the sky was overcast and rain squalls hit the ship at 0725. However, the sky cleared considerably 15 min later, and the first four launchings went off as scheduled, at 0832:06, 0842:03, 0843:18, and 0852:49. The blasts of the first four rockets loosened parts of the firing mechanisms of rockets five and six, causing delays for emergency repairs. The fifth rocket was fired at 2010:09, eight minutes later than originally planned. Because of this delay, the fifth launching coincided with the time originally planned for the last rocket. As there seemed little to be gained by firing the sixth rocket late in the final phase of the eclipse, it was held for a background measurement on the following day.

Preliminary examination of the telemetering records showed that the five rockets fired on the day of the eclipse reached peak altitudes of 139, 148, 152, 150, and 55 mi. The Lyman-alpha radiation appeared to follow the uneclipsed area of the disk very closely and almost disappeared within a few seconds after the rockets entered totality. In strong contrast, a residual flux of soft (50 Angstrom) X-rays persisted throughout totality. Measurements before second and after third contacts showed great limb-brightening in X-rays. The X-ray emission strongly resembled the kind of intensity distribution observed in radio decimeter wave measurements. Thus, the sun appears to be ringed by a bright X-ray halo.

Totality Launchings: In the totality launchings, an attempt was made to scan the region about the sun in Lyman-alpha light with an angular resolution of about 3° of arc. Unfortunately, the two totality rockets were very stable and neither developed enough yaw to scan closer than 7° to the sun. At that distance, some Lyman-alpha signal was evident in the record but quantitative evaluation of its intensity will require careful analysis of the data.

The aspect indicators used in the totality launchings were photomultiplier tubes which viewed the sky through gunsight-type reticles. The photomultipliers, which were set to receive a flux equal to half of that of full moon in the visible spectrum, were heavily over-exposed. It appeared that the airglow in the totality cone remained very high and was responsible for saturating the photomultiplier response.

Detailed analysis of the telemetering records should yield quantitative information on the residual flux of X-rays at totality. Any asymmetry produced by the presence of sunspots on the east limb and their absence on the west limb should be apparent in data recorded in the first and fourth rocket flights.

Flare Data: Unexpected data were received when the last rocket was fired, at 0839:56 on October 13. Although the shipboard group did not know it at the time, a class 2+ flare was in progress. The rocket reached peak altitude during the flare shortly after a maximum of sudden cosmic noise absorption was recorded on the island by Robert Lee, of the HAO group. The rocket performed exceptionally well and good data were received on X-ray fluxes in the 8–18 A and 44–60 A bands as well as on Lyman-alpha. The latter showed no significant variation, but the X-ray fluxes were strongly enhanced.

The degree of success achieved in this first attempt to apply rocket astronomy to the study of a solar eclipse should encourage more diversified measurements in future eclipses. It will be interesting to compare the residual X-ray flux measured at the minimum of the solar cycle with the flux observed at maximum in this year's eclipse. It is well known that the corona assumes a more or less symmetrical shape near maximum, but takes the form of long equatorial streamers at minimum. The air-

glow at totality with respect to both time and geometry would be another interesting phenomenon to scan from rocket altitudes.

Cosmic-Noise Absorption and Atmospherics Experiments

Another experiment which succeeded despite the clouds was conducted by the Sacramento Peak–High Altitude Observatory group with a device built by HAO for indirect detection of solar flares during the IGY. The detector is a "cloud-proof" instrument that measures by radio means the effects on the terrestrial ionosphere caused by enhanced short-wave radiation from the flare.

Equipment and Technique: One of the units of the detector, the SCNA (sudden cosmic-noise absorption recorder), measures at 18.5 mc/s the intensity of cosmic noise received from overhead. During a flare, ionization in the lower E-region is enhanced, causing an abrupt increase in absorption of the signal received. At the same time, the SEA (sudden enhancement of atmospherics recorder) measures the intensity of radio noise at 27 kc/s, primarily from distant thunderstorms, propagated to the antenna by D-region reflection. During a flare, the efficiency of the D-region as a mechanism for propagation of radio signals is increased, and the intensity of received atmospherics is thus enhanced. In this way, a flare is signalled by a simultaneous increase in the level of the records at 27 kc/s and a decrease at 18.5 mc/s.

Three of the SEA-SCNA instruments were built for the world-wide IGY flare detection network. One was completed in time to be taken by the Sacramento Peak-HAO group to the Danger Islands. (It was left in Hawaii on the return trip and went into operation there October 30.)

Technical Problems: Some difficulties attended operation of the equipment at Danger Island. First, the antenna was "looking at" a portion of the sky that is relatively quiet in 18.5 mc/sec cosmic noise at that season of the year in the south Pacific. Moreover, the daytime tropical ionosphere admits such frequencies of cosmic noise only to an angle of approximately 45° from the zenith; at this angle, the antenna includes within its field a portion of the E-region of the ionosphere that is not inside the region of totality. Furthermore, during the eclipse, the antenna was directed in part at a region of the ionosphere that was in total shadow for only a short time, if at all.

There were other difficulties. The site was, as anticipated, electronically noisy. In addition, voltage regulation of the power supply was poor. The effects of these difficulties were reduced to tolerable levels. However, the great density of broadcast interference in the 18-mc/s band caused additional difficulties; the Danger Islands appeared to be just the right distance from both Europe and North America to pick up a maximum of signals from stations in these areas. The SEA records, finally, proved to be of little value, probably because the principal atmospherics-producing thunderstorms were much too close at hand.

Results: In spite of these problems, useful results were obtained with the SCNA. The equipment was operated nearly continuously at the island from September 15 through October 17. Although there are inherent difficulties, it may be possible, even given the low recording level at the SCNA frequency, to distinguish in the records the daily sequence of cosmic-noise intensity by separating out, among other things, the ionospheric effects. Moreover, records of satisfactory quality were obtained on days before and after the eclipse; these provide suitable average, or standard, days for comparison with the eclipse records. In addition, records were obtained for a few days when there was high solar activity. It will be extremely interesting to compare these

with corresponding active-day records from the three SEA-SCNA instruments in the continental United States to determine if latitude and longitude effects can be discovered.

The records obtained during the eclipse itself were of good quality. Electronic noise was held to a minimum, but the need to use a short instrument time constant (because of the voltage regulation and electronic noise problems) renders the results difficult to interpret. Other factors, such as the reception of signals from near the edge of the cone of totality, also complicate the interpretation. *No* major increase in signal strength (i.e., decrease in radio-wave absorption) was recorded during the eclipse. There was a very small decrease between first and second contact, and a very small increase at totality, but it is impossible to say now whether these were real. It is possible that the absence of a major increase is evidence that X-radiation rather than Lyman-alpha is the principal ionizing agent in the lower E-region (assuming that X-rays coming primarily from the corona would be incident on the earth's atmosphere throughout the eclipse), but it is still very premature to suggest that this is the correct inference.

Trans-Antarctic Trough

The following report is based on material furnished by Albert P. Crary, Deputy Chief Scientist of the US-IGY Antarctic Program.

New evidence that East and West Antarctica may be separated by a deep, ice-filled trough was provided by the discovery recently of the greatest bottom depth yet found beneath the Ross Ice Shelf (see Fig. 3). The record depth of about 4400 ft below sea level was measured by a seismic sounding at 79°06′S, 165°30′E, during the IGY Ross Ice Shelf–Victoria Land oversnow traverse of the 1958–59 Antarctic summer season.

(The traverse, led by Albert P. Crary, left IGY Little America Station on October 15, 1958, and is expected to terminate at the Naval Air Facility, McMurdo Sound, on February 4, 1959.)

If the sounding represents a major depression in the sea floor rather than a minor feature of limited extent, it may support a 50-year-old theory that a deep trough extends beneath the vast ice sheet from the Weddell Sea to the Ross Sea, cutting Antarctica in two. The 4400-ft depth is more than twice the greatest previous sounding under the Ross Ice Shelf, which extends some 400 mi into the Ross Sea embayment from a point about 300 mi from the South Pole. Seismic studies by IGY scientists last year showed the ocean bottom to be about 2070 to 2155 ft below the ice surface.

The new low was found at a point 48 mi south of Mount Discovery and 90 mi south-

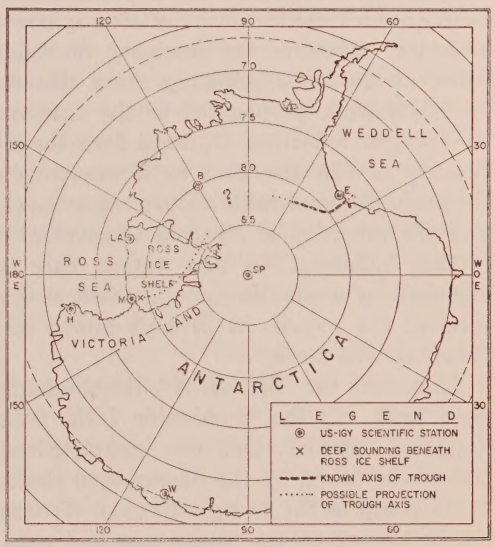

Fig. 3. *Possible Location of Hypothetical Antarctic Trough. US-IGY Antarctic Stations are Byrd (B), Little America (LA), Ellsworth (E), Wilkes (W), South Pole (SP), and the Naval Air Facility, McMurdo (M); the cooperative NZ-US Hallett Station is designated (H).*

southwest of the US Naval Air Facility at McMurdo Sound. The location would be a logical one, the traverse members feel, for a Pacific extension of the trough.

The record depth in the Ross Sea was discovered as the traverse neared the Skelton Glacier, which it ascended to the Victoria Land plateau.

The primary purposes of the Little America Station traverse this year are to study the snow and ice characteristics and obtain thicknesses over as long a line as possible into the main Antarctic highlands; to study the 100-mi-long Skelton Glacier and the geophysical aspects of the transition from the low-lying ice shelf to the high plateau; and to study in detail some anomalous water depths between IGY Little America Station and Minna Bluff, near the head of McMurdo Sound.

Antarctic Geography and Geology

The existence of an Antarctic trans-continental trough separating East and West Antarctica was first postulated by Griffith Taylor, geologist with the 1901–04 British National Antarctic Expedition, led by Robert F. Scott. Taylor based his theory on studies of Antarctic geography and the geology and geography of the nearby continents of South America and Australia.

Antarctica may be divided into two distinct segments on the basis of its geographic and geologic character. East Antarctica lies mostly east of the 0°–180° meridian, and hence is mostly within the eastern hemisphere. It consists of a vast, elevated "shield" of Pre-Cambrian rocks—rocks over 500 million years old. This very ancient "basement complex" is composed essentially of metamorphic rocks intruded by igneous rocks. These are overlaid by a thick series of younger, flat-lying sedimentary rocks, also intruded in many places by igneous materials. Upon these rests the great ice sheet of the south polar plateau.

West Antarctica is characterized primarily by folded ranges and plateaus of metamorphic rocks and igneous intrusives similar to those of the Andes of South America. These are also overlaid by younger sediments and the thick mantle of Antarctic ice. The structure of West Antarctica can be traced through the Palmer Peninsula and the sub-oceanic Scotia Arc to the Andes.

The edge of the East Antarctic shield along the Ross Sea has been found to be a horst region—a linear block of the earth's crust that has been uplifted along faults, or breaks in the crust. This horst zone may extend completely across the continent to the Weddell Sea. Such structures are generally paralleled by down-dropped, trough-like blocks called grabens. Other examples of this horst and graben structure are the Rhine Valley of Germany and parts of the "basin and range" region of the Western United States.

The existence of the trough is also suggested by the deep penetration into the interior of Antarctica of the Ross Sea, on the Pacific side of the continent, and the Weddell Sea, on the Atlantic side.

Related IGY Findings

An IGY scientific traverse party from Ellsworth Station on the Weddell Sea coast last year detected a deep trough extending inland from the Filchner Ice Shelf (see *Bulletin No. 14*). The bottom of the trough was found to average almost 4000 ft below sea level, and the traverse party reported that the trough continued beyond the southerly limits of the traverse, swinging toward the southwest. This may represent the Weddell Sea side of the hypothetical trans-Antarctic trough (Fig. 3).

At approximately 80°15′S, 113°W, near the end of the final leg of the 1957–58 US-IGY oversnow traverse from Byrd Station, the surface beneath the 14,000-ft thick ice sheet was found to be more than 8000 ft below sea level (see *Bulletins 10* and *14*).

Further Studies

Further work is in progress during the present Antarctic summer to determine

whether the trough extends all the way to the deep basin discovered earlier in Marie Byrd Land and from there to the Ross Sea. A Byrd IGY Station traverse, led by Charles R. Bentley, is now en route to the Horlick Mountains, which extend eastward from the southeast corner of the Ross Ice Shelf, making geophysical studies that are expected to help solve the problem of the trough's existence and exact location. An IGY airborne traverse is about to launch a series of seismic and gravity measurements in Marie Byrd Land to seek further evidence as to whether the ice-filled basin found there by members of the 1957–58 Byrd Station traverse may be part of the hypothetical trough connecting the Ross and Weddell Seas.

World Warning Agency Decisions

July 1—September 30, 1958

Bulletins 2, 5, *and* 10 *describe the IGY World Days Program and the function of the IGY World Warning Agency (AGIWARN);* Bulletins 5, 10, *and* 14 *list earlier AGIWARN decisions.*

Although the over-all level of solar activity was fairly high throughout the period July 1–September 30, 1958, geomagnetic conditions varied considerably. Geomagnetic activity was high in July, being exceeded only during two other months since the IGY began on July 1, 1957. In August, there was a sharp drop. September showed about the same average level of activity as August, but its median level was the lowest of any month yet recorded during the IGY; this was owing to two extremely quiet periods, September 10–15 and 18–24.

Eleven geomagnetic disturbances occurred, well distributed through the entire period. Three severe geomagnetic storms were observed, one during each of the three months. Eight of the 11 disturbances occurred during the seven periods of Alert that were declared by AGIWARN, and only one Alert was not followed by a storm. Of the five Special World Intervals (SWI) that were in effect, totaling nine days, only one was not followed by a disturbance. Two of the three severe geomagnetic storms occurred during SWI.

A list of Alerts, SWI, major geomagnetic disturbances, and major flares that occurred between July 1 and September 30, 1958, follows, with the Alerts numbered chronologically from #27, which ended on June 23, and the SWI from #13, which ended on June 22, 1958.

Jul	5	1600	Alert #28 starts
	7	0039	Class 3+ flare; gradual ionospheric disturbance
	8	0001	SWI #14 starts
		0619	Class 3 flare
		0749	Geomagnetic storm begins
	9	2359	SWI #19 finishes
	10	06xx	Geomagnetic storm ends
	11	0752	Class 3 flare
		0825	Class 3 flare
	14	1600	Alert #28 finishes
Jul	20	0636	Class 3 flare
		1203	Class 3 flare
		1600	Alert #29 starts
	21	1638	Geomagnetic storm begins
	22	1600	Alert #29 finishes
		23xx	Geomagnetic storm ends
Jul	23	1131	Class 3 flare
	24	1600	Alert #30 starts
	27	0856	Class 3 flare
	29	0303	Class 3 flare; sudden ionosphere drop-out and gradual recovery
	30	0001	SWI #15 starts
	31	2359	SWI #15 finishes
Aug	4	0421	Class 3 flare; gradual ionospheric disturbance
		1600	Alert #30 finishes
Aug	7	1500	Class 3 flare; sudden ionosphere drop-out and gradual recovery
Aug	11	1600	Alert #31 starts
	15	1600	Alert #31 finishes

Aug 16	0432	Class 3+ flare; sudden ionosphere drop-out and gradual recovery
	1600	Alert #32 starts
17	0001	SWI #16 starts
	0623	Magnetic storm begins
18	17xx	Magnetic storm ends
	2359	SWI #16 finishes
20	0043	Class 3 flare; sudden ionosphere drop-out and gradual recovery
22	1417	Class 3 flare
23	1013	Class 3 flare
24	0001	SWI #17 starts
	0140	Magnetic storm begins
	2359	SWI #17 finishes
25	15xx	Magnetic storm ends
	1600	Alert #32 finishes
Aug 26	0005	Class 3 flare; slow ionospheric disturbance
	1600	Alert #33 starts
27	0001	SWI #18 starts
	02xx	Magnetic storm begins
28	00xx	Magnetic storm ends
	2359	SWI #18 finishes
29	1600	Alert #33 finishes
Aug 30	1943	Class 3 flare, gradual ionospheric disturbance
Sept 3	0842	Magnetic storm begins
6	00xx	Magnetic storm ends
7	1448	Class 3+ flare; sudden ionosphere drop-out and gradual recovery
9	1425	Class 3+ flare
10	1600	Alert #34 starts
12	0908	Class 3 flare
13	0911	Class 3 flare
14	0832	Class 3+ flare; sudden ionosphere drop-out and gradual recovery
16	1444	Class 3 flare; sudden ionosphere drop-out and gradual recovery
18	0730	Class 3 flare; sudden ionosphere drop-out and gradual recovery
	1600	Alert #34 finishes
Sept 25	0408	Magnetic storm begins
26	11xx	Magnetic storm ends

A meeting of the Working Group for World Days and Communications was held at the Fifth IGY Assembly, in Moscow, July 29–August 9, 1958. It was the consensus among representatives of all participating disciplines that the World Days Program has been highly successful, and it was recommended that similar programs carry on this work on an international basis after the close of the IGY.

Apogee Moonwatch Stations

Material for this report was furnished by Richard Tousey, Naval Research Laboratory, Washington. D. C.

The standard 5½-power telescope used in the IGY Moonwatch program for visual observation of satellites can detect objects as faint as 8th magnitude against a dark nighttime sky. (Magnitude is a measure of star brightness used by astronomers; the higher the number the fainter the object.) This corresponds to the ability to detect a polished 21-in sphere approximately 750 mi above the surface of the earth at the observer's zenith. However, calculations prior to the IGY showed that some US satellites might rise as high as 2500 mi at apogee (the point in the orbit farthest from earth). The 6-in Vanguard test sphere, 1958 Beta 2, reaches almost this height at apogee. At this height, a 21-in sphere would appear no brighter than 11th magnitude when at the zenith.

Satellites viewed at low angles above the horizon would be even fainter than 11th magnitude because of the increased distance from the observer and the increased thickness of atmosphere through which the light reflected by the satellite must penetrate. Moreover, the visibility of a satellite depends not only on its brightness and its elevation above the horizon but also on the ability of the human eye to detect a faint object moving through the twilight sky or past the fixed stars at night. To insure maximum coverage of newly launched satellites with high orbits, eight "apogee" stations using specially designed high-power telescopes have been set up at strategic locations.

When the need for improved observation first became apparent the Naval Research Laboratory constructed a "satellite simulator," which presents to the observer an image similar to that actually made by a

satellite moving across the sky. All elements of the scene shown in the simulator are adjustable. The luminosity of the sky background, the brightness and number of stars in the field, and the brightness, altitude, and movement of the satellite can be varied to reproduce any desired situation. Figure 4 shows the optical arrangement of the simulator.

The Telescope

Experiments with the simulator showed that an 8-power telescope such as the US Army M-17 elbow telescope can detect a 21-in satellite at heights of 1000–1200 mi. For viewing beyond this distance a larger-aperture, higher-magnification telescope must be used. To meet this need, a 21½-power instrument having an aperture of 120 mm and a field of view of 2¼°, was designed and a number were constructed by the Optical Shop of the Naval Gun Factory. It combines the objective lens of the US Navy Mark-I ship's binoculars with the prism and eye-piece unit of the M-17 elbow telescope. It has a special reticle (shown in Fig. 5) to assist in establishing time and position for the observation. The crosshair is illuminated by a controllable red light that does not impair the viewer's adaptation to darkness.

In use, the telescope is aimed so that the central circle is on the meridian at the desired zenith angle. Because the simulator experiments had shown that an observer rarely detected a faint object until it approached the center of the field of view, the crosshair is parallel to the meridian, but offset 0.4° in the direction of satellite travel. This allows the observer more time to signal the satellite's transit over the crosshair. The crosshair is divided into ¼° segments, allowing moderately accurate estimates of zenith angle.

Since the 21½-power telescope has 2.7 times the aperture diameter of the M-17, it makes equally visible a satellite 2.7^2 times

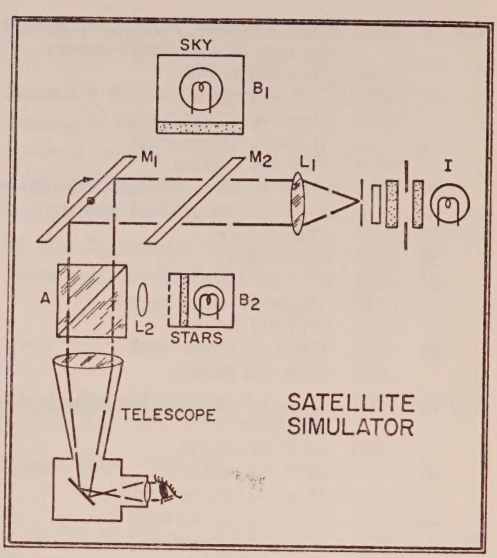

Fig. 4. *Satellite Simulator. The observer, looking through an elbow telescope of the type used in the Moonwatch program, sees a star field produced by pinholes in a plate; light from lamp B_2 passes through the pinholes and lens L_2 and is reflected in by a beam splitter, A. The observer also sees a uniform twilight sky produced by light from lamp B_1 reflected in by beam-splitting mirror M_2. The satellite image is produced by a small pinhole on the focus of lens L_1; it is illuminated and its magnitude controlled by the system I. The satellite image is moved by rotating mirror M_1 at the desired speed.*

fainter. This corresponds to an object 2.7 times farther away. However, this is the same amount by which the 21½-power field is narrower than that of the M-17. Therefore, the 21½-power telescope affords about the same lateral coverage in miles as the M-17 does for a satellite 2.7 times closer.

The instruments may be used interchangeably on the mounting, which consists of an adjustable bracket attached to the top of a rigid 2½-in pipe set in concrete. Azimuth is set by rotation of the bracket on the vertical pipe. The mounting head provides for adjustment to the plane of the meridian and for elevation. An instrument can be quickly removed when the locking screws on either side of the mounting are loosened.

Locations of Stations

Two groups of stations are used in the apogee Moonwatch network. The first group is in South Africa, where skies are usually very clear. Under the direction of C. G. Hide, secretary of the South African National Council for the IGY, and David S. Evans, South African Moonwatch coordinator, stations have been located in Capetown, Bloemfontein, Johannesburg, and Pretoria. Observers at these stations may see the second pass of a US satellite as well as the first.

The South African stations are located so that their considerable north-south separation provides a wide observation fan for coverage of all predicted satellite orbits. These stations are so situated that for four months of the South African summer, satellites are sunlit all night over some part of the fan.

The second group of stations is arranged in a network in the United States. Good sky conditions over a large area could be found only in the Southwest; hence, apogee stations were established at Kirtland Air Force Base, Albuquerque, New Mexico; Holloman Air Force Base, Alamogordo, New Mexico; Naval Ordnance Test Station, Inyokern, California; and Vincent Air Force Base, Yuma, Arizona.

The Albuquerque and Alamogordo stations are roughly on a north-south line, while Inyokern and Yuma form a similar pair farther to the west. The east-west separation of the pairs produces a difference in sunset times of about 40 min; thus, one pair or the other will be in a favorable position for a twilight passage of a new satellite. Also, the northern stations are located near 35°N latitude, and can, therefore, observe satellites in orbits inclined more than 35° to the equator. To the south, coverage extends well below the Mexican border, as the Yuma and Alamogordo stations are able to detect a 21-in sphere 2000 mi high passing over a point as much as 1000 mi south of them.

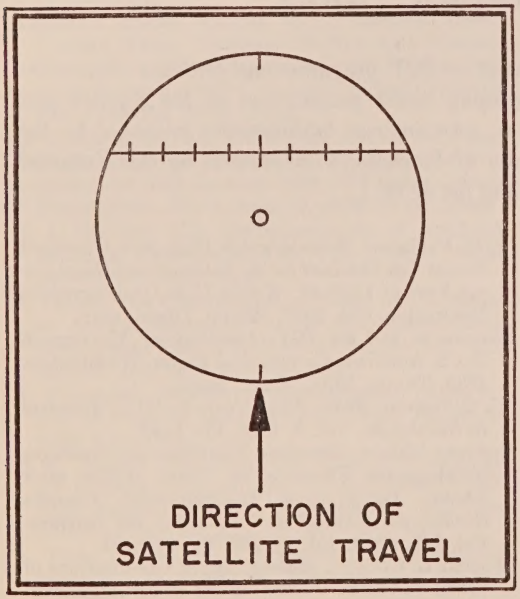

Fig. 5. *Reticle of High-Power Apogee Moonwatch Telescope. Offset crosshair gives observer more time to signal satellite's transit across it.*

Observing Techniques

A fully-instrumented US apogee station has 37 telescope mounts, 37 eight-power telescopes, and the same number of 21½-power instruments. Both types of telescopes can be used on the same mounts. The 8-power telescopes are set with their fields of view centered 2½° apart along the meridian, down to 45° on either side of the zenith. As the field of each instrument is 6°, two observers, sometimes three, should see a satellite simultaneously. This minimizes the chance of a false report and increases the probability of detecting an actual satellite passage. In the high-power array, the 21½-power instruments are pointed 1° apart, so that their 2¼° fields overlap considerably.

In looking for a satellite whose position is completely unknown, the plan for the US apogee stations during evening twilight is first to use the 8-power telescopes, begin-

ning when the sun is 5° below the horizon and the sky is dark enough to see a bright, low object. The wide fields of the 8-power instruments give extended coverage along the meridian needed for low satellites.

Each station will watch for about an hour, the western pair beginning about 40 min after the eastern pair; the total observing time is, therefore, about 100 min. This is roughly long enough for a satellite to travel from the eastern stations around the earth to the western stations, where a low satellite would still be sunlit. For longer revolution periods, the observing time may be lengthened by special techniques, such as tilting the meridian array in the direction of the sun for part of the time.

If the satellite is not detected by either pair of stations, it will be assumed to be too high for the 8-power telescopes, and 21½-power instruments will be placed on the mounts instead. By this time the sky will have reached its full nighttime darkness, but there would be at least 100 min during which a high satellite could be sunlit while within viewing range of some part of the network. For observing during morning twilight the plan would be reversed, with low-power instruments replacing the 21½-power instruments as the sky changes from full night to twilight.

Experience has shown that failure of radio transmitters upon launching is one of the less likely hazards connected with satellites; however, visual observations have made it possible to determine orbits for objects that have not carried radios, such as final stages of launching vehicles. Because the apogee stations are especially well-equipped to detect faint satellites, they have already contributed valuable reports on 1958 Alpha, Beta, and Gamma.

IGY Bibliographic Notes

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